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Biological and physical data were collected from four bendways within the river portion of the Tennessee-Tombigbee Waterway (TTW) from Columbus, Mississippi, to Demopolis, Alabama: Rattlesnake Bend, Cooks Bend, Big Creek Bendway, and Hairston Bend. During this study, the four bendways had not all been cut off and had been impounded for various lengths of time. At the completion of the TTW project, all four of the bendways will be severed from

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the main navigation channel. Four distinct areas within each bendway were compared: above the bendway, within the bendway, below the bendway, and within the cut. Sampling was conducted from January 1979 to September 1980 to coincide with four different river stage/water temperature regimes.

Sediment analysis and bottom profiles indicated that the substrate composition of some of the bendways is changing. Overall, the substrate of the study area is changing from a sand-gravel-fines mixture to one of predominantly sand and fines. Areas of some bendways, in particular the upper areas, were accumulating sediments. At Big Creek Bendway, this accumulation completely blocked water exchange between the river and the within-bendway areas.

Few significant differences in water quality were documented for either within individual bendways or among the four bendways. Only at Big Creek Bendway were consistent differences found between within-bendway samples and river samples.

Phytoplankton composition and chlorophyll concentrations showed only small differences among bendways.

Aquatic macrophytes were scattered and uncommon in the four bendways. Water-willow (Justicia sp.) was most commonly encountered, particularly in Rattlesnake Bend where numerous small beds were found.

Based upon total collections, a consistent family assemblage of macroinvertebrates characterized the four bendways. Although 60 family-level taxa were collected, nine families of macroinvertebrates accounted for between 93.5 and 97.2 percent of the benthos. The importance of these families varied among bendways and appeared to reflect differences in physical bendway conditions, particularly substrate type and current velocities.

Eighteen species of Unionid mollusks, plus the Asian clam Corbicula, were collected during the surveys. Nearly all the specimens were found at Big Creek Bendway; none were collected at Hairston Bend. With the exception of three species of Pleurobema, no unusual or uncommon mollusk species were found.

Based on overall ichthyofaunas, two groups of bendways were delineated that corresponded to impoundment and riverine habitats. Rattlesnake Bend and Cooks Bend were located in lower pool sections, where impoundment conditions prevailed, and their ichthyofaunas were dominated by clupeids (shad) and centrarchids (sunfishes, crappies, and basses). Hairston Bend, essentially a riverine reach during this study, was dominated by cyprinids (minnows), ictalurids (catfishes), and catostomids (suckers). Big Creek Bendway, unique in having both riverine and lacustrine habitats, was faunistically most similar to Hairston Bend, but also showed moderate similarities to the other bendways.

Preface

The study described in this report was sponsored by the Office, Chief of Engineers, U. S. Army, under the Environmental and Water Quality Operational Studies (EWQOS) Program, Work Unit VIIB, Waterway Field Studies: Long-Term Field Studies Associated with the Environmental Quality of the Tennessee-Tombigbee Waterway Project. The EWQOS Program has been assigned to the U. S. Army Engineer Waterways Experiment Station (WES) under the direction of the Environmental Laboratory (EL).

This report presents summary results of a study of physical, chemical, and biological characteristics of four cutoff bendways in the Tombigbee River between Demopolis, Alabama, and Columbus, Mississippi, conducted during 1979 and 1980. Portions of the data (1980) were collected for WES by the U. S. Fish and Wildlife Service, Mississippi Cooperative Wildlife and Fisheries Research Unit, Dr. Robert J. Muncy, leader, under Interagency Agreement No. WES-79-12. Drs. H. Randall Robinette, Principal Investigator, and Edward J. Harrison and Wendell J. Lorio, Co-principal Investigators, of the Department of Wildlife and Fisheries, Mississippi State University, were instrumental in the successful completion of the Interagency Agreement and their effort is greatly appreciated. This summary was prepared at the request of the U. S. Army Engineer District, Mobile, and appeared as Appendix H in the Supplement to the Environmental Impact Statement.

The report was prepared by Dr. C. H. Pennington and Mr. J. A. Baker under the direction of Dr. Thomas D. Wright, Chief, Aquatic Habitat Group; Mr. Bob O. Benn, Chief, Environmental Systems Division; Dr. Jerome L. Mahloch, Program Manager, EWQOS; and Dr. John Harrison, Chief, EL. Technical manuscript review was provided by both Mobile District and WES personnel, and editorial review was provided by Ms. Dorothy P. Booth, EL.

The Commanders and Directors of WES during the study and the preparation of this report were COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. Fred R. Brown.

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ENVIRONMENTAL EFFECTS OF TENNESSEE-TOMBIGBEE PROJECT CUTOFF BENDWAYS

Introduction

1. Construction of cutoff channels is common practice. Many have been constructed by private drainage districts, by the U. S. Soil Conservation Service under the small watershed program of Public Law 566 - Watershed Protection and Flood Prevention Act, and by the U. S. Army Corps of Engineers as part of Waterway navigation projects (Emerson 1971). The cutoff channels are formed by excavating a new channel across the neck of a bendway or meander loop for the purpose of channel alignment, reducing the river's length, and increasing the ability of the river to carry flows. The resulting cutoff bendways, often analogous to oxbow lakes, change physically and the habitat becomes modified from that found in the main stem of the river. Effects of the habitat changes are not fully understood, but some bendways offer excellent potential for recreation, fish, and wildlife while others may be of limited value after being cut off.

2. The 148-mile river section of the Tennessee-Tombigbee Waterway (TTW) which extends from Demopolis, Alabama, to Amory, Mississippi, has a series of bendways that have been or will be cut off. However, the data base for evaluating effects of the cutoffs is extremely limited. A two-year field-oriented study was conducted by the U. S. Army Engineer Waterways Experiment Station (WES) for the purpose of establishing a sound basis to evaluate ecological impacts associated with severing bendways from the main stem of the river. Cutoff bendways are not unique to the TTW construction but are common in the natural condition of meandering streams and wherever river navigation projects occur. For this reason, a better understanding of natural and man-made processes and their subsequent effect on the biota of the TTW may point to various management strategies for developing and utilizing the potential of cutoff bendways.

3. The purpose of this report is to present a summary of results

of a study conducted from January 1979 through August 1980 at four bendways located in the river section of the TTW and to compare those results with existing data. The study was conducted to document physical and biological changes associated with bendway severance. Specifics of the bendway study can be found in WES Technical Report E-81-14 (Pennington et al. 1981).

Description of Study Area

4. The study sites are within the river section of the TTW and are located between Demopolis, Alabama, and Columbus, Mississippi (Figure 1). When the TTW is complete, all four of the selected bendways will be severed from the main navigation channel. The four bendways are of different ages and sizes and in different positions in the navigation pools. None will be inundated when the pools are formed by closure of the locks and dams. Sampling was conducted in the river reaches above and below the cut, within the cut, and within the cutoff bendway (Figure 2). A description of each study site follows.

- a. Rattlesnake Bend is part of the boundary between Greene and Sumter Counties, Alabama, and is located at river mile 223 within the Demopolis Pool section of the waterway. The 1.1-mile cut was completed in 1976, and the resulting bendway is approximately 10 miles in length.
- b. Cooks Bend is located in Sumter County, Alabama, within the Gainesville Pool section of the waterway at river mile 277. The 1.0-mile cut was completed in January 1980, midway through the study. This bendway is approximately 4 river miles in length.
- c. Big Creek Bendway is located in Pickens County, Alabama, at river mile 305 within the Gainesville Pool immediately below the Aliceville Lock and Dam. The 1.1-mile cut was completed in 1979, and the resulting cutoff bendway is approximately 3 river miles in length.
- d. Hairston Bend is located in Lowndes County, Mississippi, at approximately river mile 318 about midway between Columbus, Mississippi, and Pickensville, Alabama, in the Aliceville Pool section of the waterway. This bendway is 5 river miles in length and was not cut off during the study period.

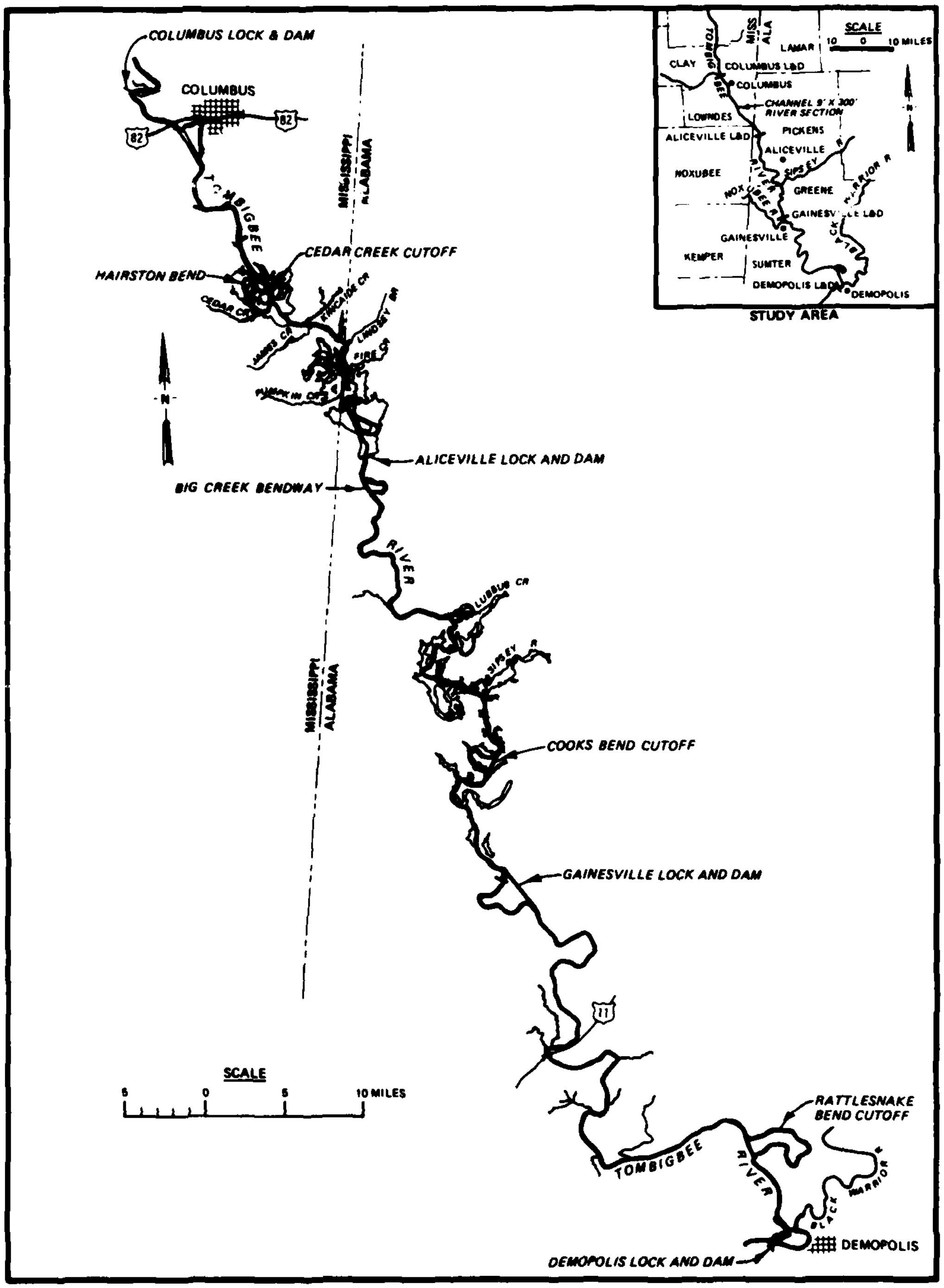

Figure 1. Map cf study site

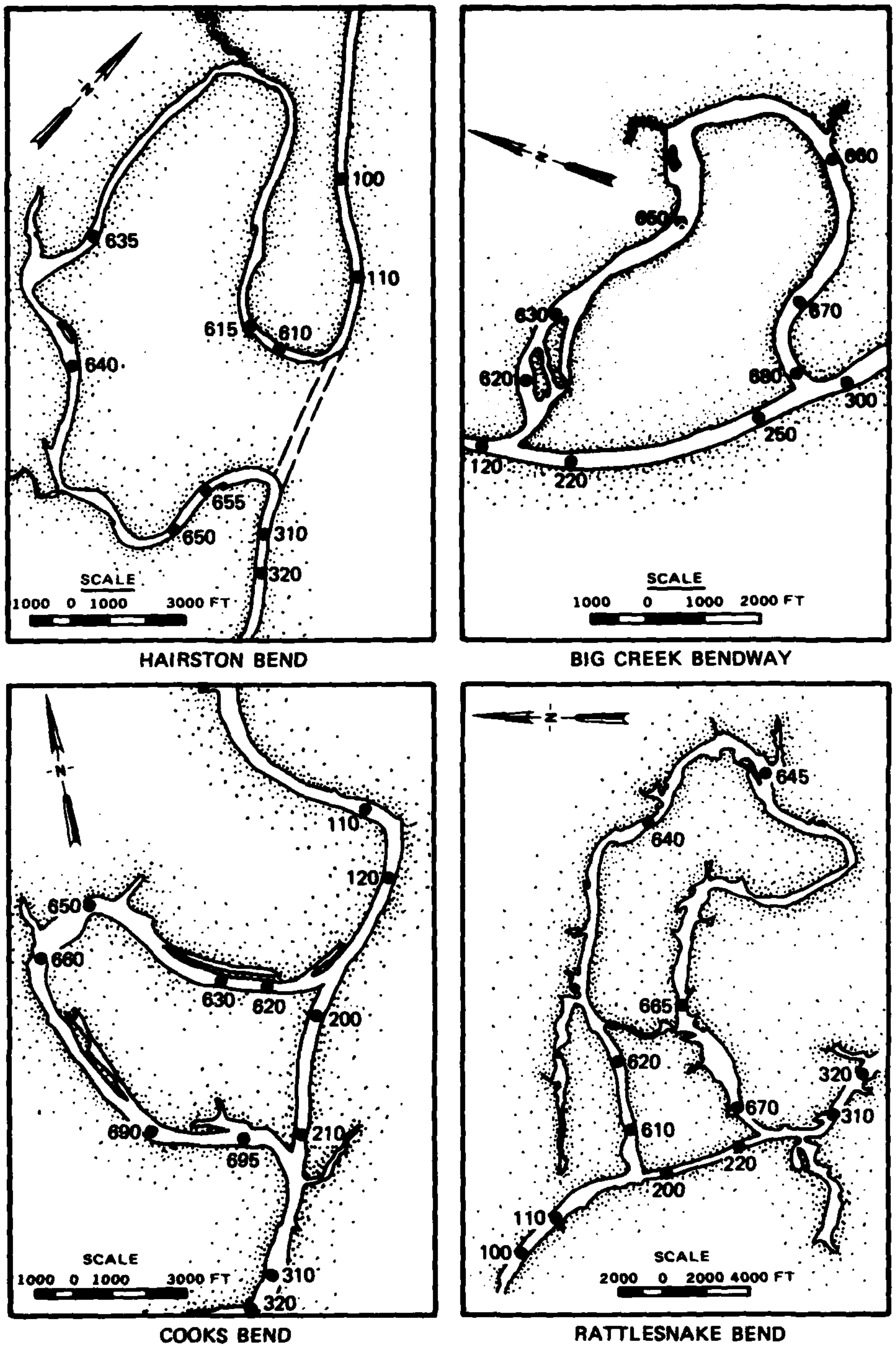

Figure 2. Transect locations. Transects at each site were numbered according to the following scheme: 100s - above the cut; 200s - within the cut; 300s - below the cut; and 600s - within the cutoff bendway

Discussion

5. When bendways are cut off from the river's main channel through natural or man-made processes, certain physical and biological changes will occur. For example, currents will be altered in the bendway, affecting sediment load and deposition, water quality, plankton, invertebrates, and fishes. Following is a discussion of the physical and biological conditions that existed in the four bendways from January 1979 through August 1980.

Physical conditions

6. Sediments. Although some gravel was present at a few transects at Big Creek Bendway and Cooks Bend and at most Hairston Bend midchannel transects, sand and fines comprised most of the substrate at all four bendways. Changes in bottom profile and sediment composition have occurred at some bendways since impoundment and since completion o the channel cuts. At Big Creek Bendway, the upper portion of the cutoff bendway has rapidly filled since completion of the channel cut, effectively isolating the bend from the river proper (Figure 3). This sedimentation effect can be seen in the lower reaches of the cutoff bendway though not to the same extent. In addition, the substrate in the cutoff bendway is changing from sand and gravel to predominantly fines. Except for the river reach above the cutoff bendway, which is influenced by flows through the Aliceville Lock and Dam, the river at this bendway is changing from a mixed substrate to one of mostly sand and fines.

7. Some deposition of sand and fines is occurring in the upper cutoff bendway area of Cooks Bend, but not to the extent that it is occurring at Big Creek Bendway. The overall sediment composition at this bendway has not changed greatly since the original surveys in 1979, although some silting in the cutoff bendway has occurred.

8. Upstream transects at Rattlesnake Bend showed some sand deposition (Figure 4). At this area, sand is gradually replacing fines as the dominant substrate material. No other area showed any significant depth or sediment composition change at this bendway.

9. Both channelization and impoundment are affecting the

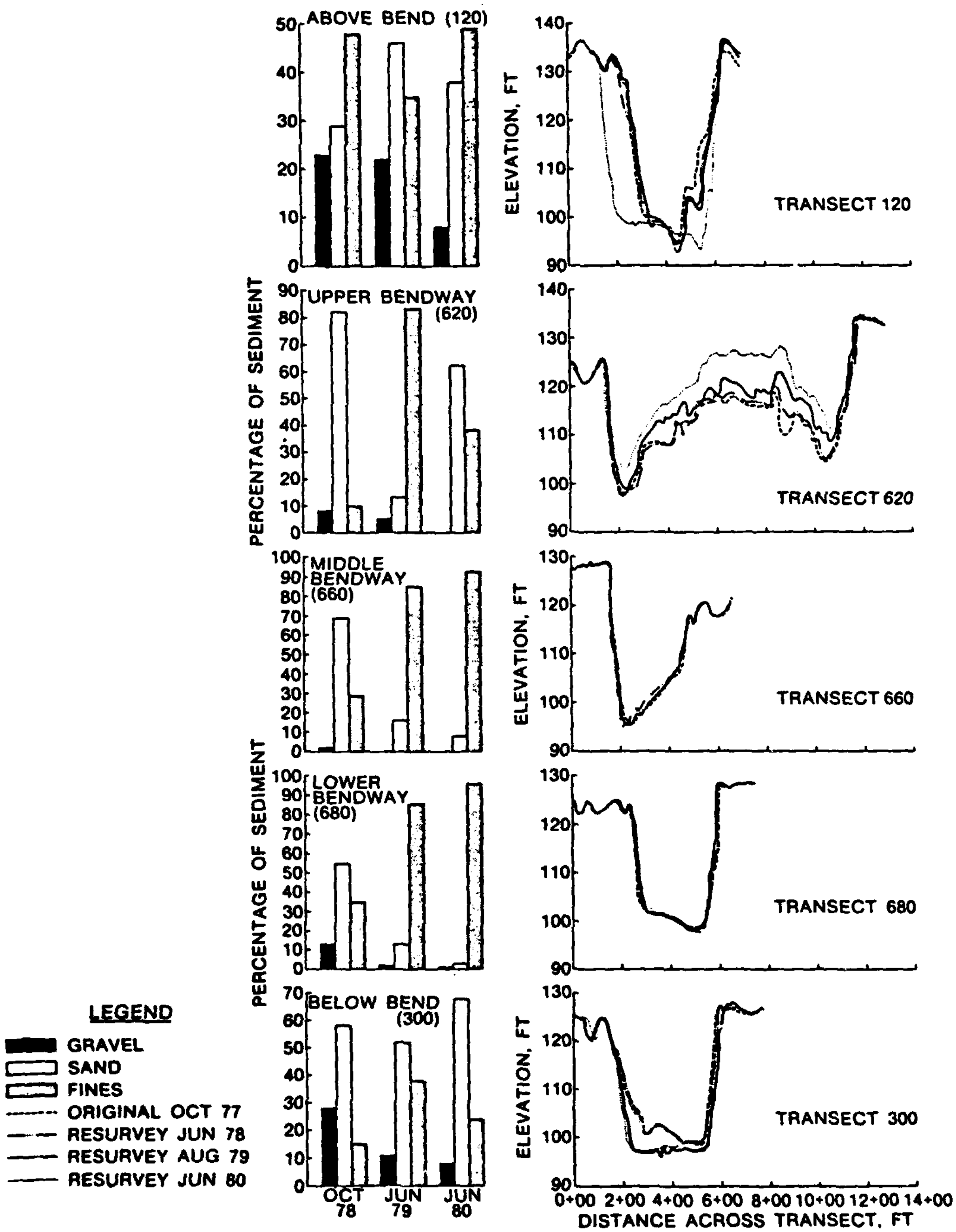

Figure 3. Sediment grain-size composition and depth profiles of five cross channel transects at Big Creek Bendway

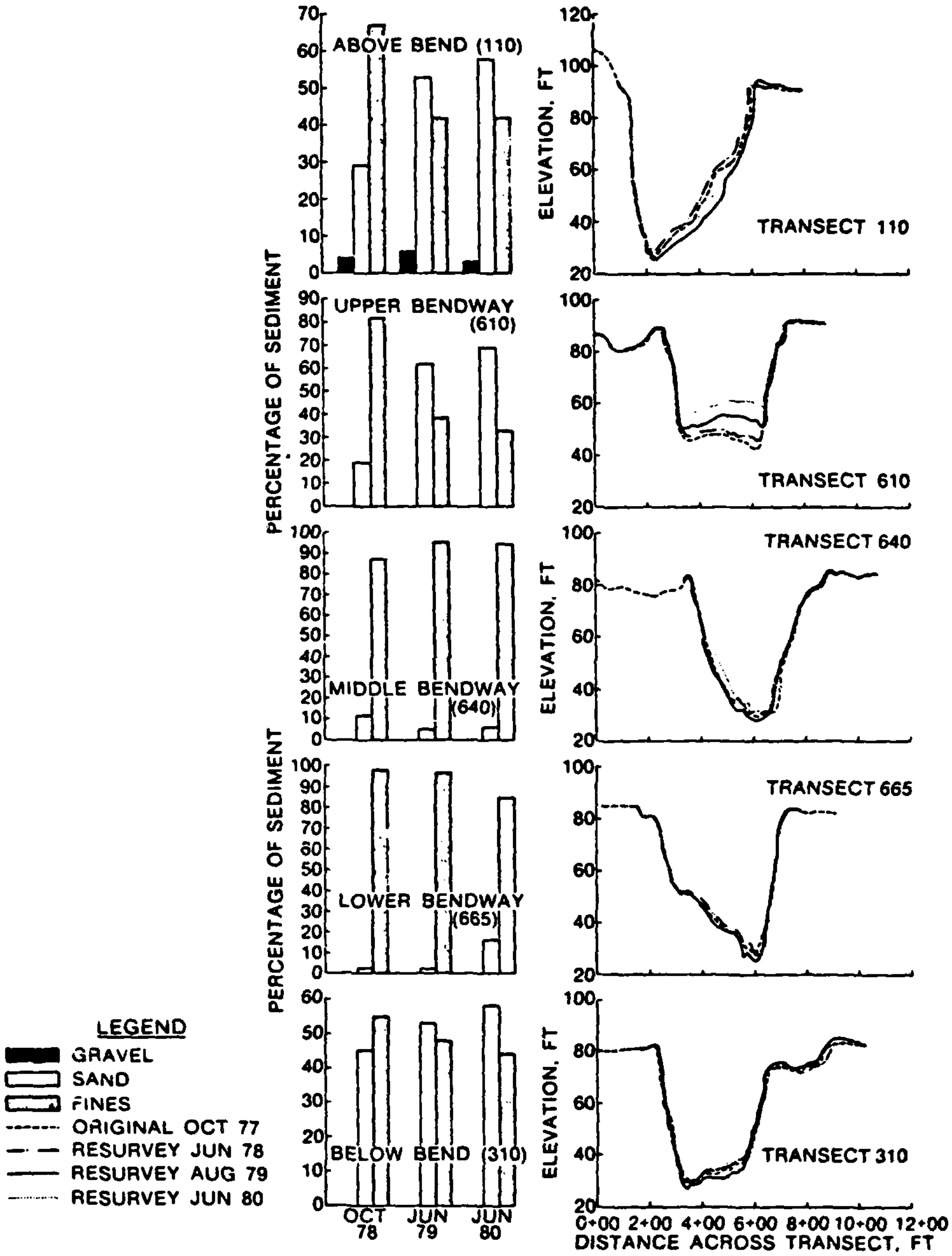

Figure 4. Sediment grain-size composition and depth profiles of five cross channel transects at Rattlesnake Bend

substrate composition of the cutoff bendways on the Tombigbee River. Shortened channelized streams generally carry greater sediment loads than meandering streams (Leopold et al. 1964, Hansen 1971, Henegar and Harmon 1971, Arner et al. 1976, and Schmal and Sanders 1978). These sediment loads tend to settle out in areas of reduced currents, such as cutoff bendways.

10. Currents. Currents were often considerably higher within the bendway at Hairston Bend than at the cutoff bendways because the flow through this area was not diverted by a cut. Comparing river sections, current velocities at Hairston Bend were similar to those of the other bendways and were actually lower than velocities at Big Creek Bendway during May 1980. Hairston Bend was not affected by pooling until relatively late in the study. Of the four study bendways, only the river reach at Big Creek Bendway, which is influenced by the Aliceville Lock and Dam tailwaters, will likely retain habitats having swift currents.

11. Water quality. Several factors are operating concurrently on the Tombigbee River that can potentially affect water quality, some of which are associated with the construction of the TTW. Factors involved with construction of the waterway include channel modification by dredging, pooling behind a series of locks and dams, and cutting off of bendways. Comparisons of water quality investigations on the Tombigbee River (Taylor 1964, Cotton et al. 1969, Schultz 1971, Brahana et al. 1974, Howell et al. 1978, Shell 1978, Harmon Engineering and Testing 1980, and Mercante 1980) indicate that for the years since 1964, the water quality of the Tombigbee River has not changed appreciably.

12. The river is in the process of changing from a free-flowing system to a series of shallow in-stream impoundments. In conjunction with this change, additional development of the immediate area (recreational, industrial, etc.) can be expected. When completed, the waterway will receive water from the Tennessee River, which is outside its natural watershed (Brahana et al. 1974). All these factors suggest that the water quality of the river will undergo future changes. However, during this study relatively small differences in water quality were found, either within individual bendways or among the four bendways.

13. Rattlesnake Bend and Cooks Bend had slightly higher annual mean surface dissolved oxygen levels than did Big Creek Bendway or Hairston Bend (approximately 8 mg/ℓ vs 7 mg/ℓ). Main channel vertical profile differences were smaller. Dissolved oxygen levels varied considerably among seasons at all bendways. During late summer there was dissolved oxygen depletion (dissolved oxygen less than 3 mg/ℓ) in bottom waters of most stations within the cutoff bendways.

14. Hairston Bend was consistently cooler (up to 2.2°C) than other bendways at any sampling date. During winter, the cutoff bendway portion of Big Creek Bendway was warmer than the river reach; other bendways showed more homogenous temperatures.

15. The pH at Rattlesnake Bend was generally slightly higher than at other bendways. Big Creek Bendway was the only bendway at which consistent transect differences occurred; river transects tended to have higher pH values than values measured at cutoff bendway transects.

16. Big Creek Bendway had statistically significant lower Secchi visibilities than other bendways and was again the only one at which significant transect differences occurred. At this site, the river transects were clearer than transects in the cutoff bendway during summer phytoplankton peaks.

17. Conductivity readings were much higher in the cutoff bendway at Big Creek Bendway than at other bendways. River transect conductivities were generally similar at all bendways.

18. Hairston Bend and Big Creek Bendway were considerably more turbid than Cooks Bend or Rattlesnake Bend at any sampling period.

19. There were no differences in ammonia-nitrogen concentrations at river stations. Bendway concentrations showed Hairston Bend to be higher than all others in August 1980 by 5 to 278 times. This may have resulted from measurement error or from a localized phenomenon of unknown origin.

20. Hairston Bend and Big Creek Bendway had higher carbon dioxide and orthophosphate values than either Cooks Bend or Rattlesnake Bend. Concentrations at Big Creek Bendway were especially high at cutoff bendway transects. Big Creek Bendway also had higher total alkalinity and

total phosphorus than the other bendways.

21. It is difficult, if not impossible, to separate the effects of the channel cutoffs from the effects of pooling following lock and dam closure. Within the study area, pooling may be the most important factor affecting changes at Rattlesnake and Cooks Bends, while at Big Creek Bendway, the channel cutoff may have a greater ecological impact.

22. In either case, one of the most important effects is a reduction in current velocities. The reduction of currents affects water quality in several ways. Mixing of the water column is diminished, potentially leading to lowered dissolved oxygen in lower strata at some seasons (Brahana et al. 1974). Turbidity may be reduced due to sedimentation in some areas and increased in others due to increases of phytoplankton populations through lack of flushing. Greater diel fluctuations in such variables as pH, carbon dioxide, and dissolved oxygen may occur. Other studies have documented little change in water chemistry from channelization other than some increases in turbidity (Arner et al. 1976, Duvel et al. 1976, Kuenzler et al. 1977, Schmal and Sanders 1978).

Biological conditions

23. Phytoplankton. Phytoplankton densities were greater at cutoff bendway stations than in river stations at Big Creek Bendway and Cooks Bend and approximately equal at all transects at Hairston and Rattlesnake Bends. There were only small differences in the kinds and abundance of plankton at the four bendways. Phytoplankton populations showed a seasonal pattern of low numbers in December and peak numbers in August.

24. Phytoplankton populations will likely remain higher in the cutoff bendways and in the slower waters above the locks and dams than in the river reaches (Hynes 1971). The eventual plankton community of the system will ultimately depend upon the retention time of the water in the cutoff bendways and in the pools behind the locks and dams (Brook and Woodward 1956).

25. Aquatic macrophytes. Aquatic macrophytes were scattered and uncommon in the four study bendways. Most commonly encountered was

water willow (Justicia americana), which formed small, though numerous, beds in Rattlesnake Bend. Development of macrophytes can be expected in portions of the waterway where sedimentation creates shallow organic-matter-enriched habitats (Boyd 1971 and Hynes 1971). Wilkinson (1973) noted that this had occurred in cutoff oxbows along the Kissimmee River in Florida.

26. Although not as well studied as other biological aspects of river systems, macrophytes appear to form an important component of aquatic ecosystems (Boyd 1971, Modde and Schmulbach 1973, Schmulbach 1974, Westlake 1975, and Haslam 1978). They provide fish shelter, invertebrate habitat, waterfowl food, and substrate stabilization and may greatly influence nutrient cycling (Boyd 1971).

27. Macroinvertebrates. All bendway macroinvertebrate collections can be characterized by a common benthic community, at least at the family level of classification. Nine families, shared by all four bendways, accounted for over 95 percent of the total number. The four bendways cannot be distinguished statistically by average number of taxa, density of individuals, or family diversity. The macroinvertebrate assemblage in the four bendways decreased in qualitative similarity with increasing distance between the bendways and increased in quantitative similarity according to date of bendway cutoff.

28. While the dominant family assemblage was consistent among bendways, the importance of particular families differed among the bendways and appeared to reflect their respective physical conditions. Two groups known to be associated with sand-silt substrates (Sphaeriidae and Ephemeridae) contributed substantially to the benthic macroinvertebrate community at Rattlesnake Bend.

29. Fuller (1974) pointed out that Sphaerium is especially tolerant of impoundments, and Grantham (1969) suggested that sphaeriids have value as indicators of environmental disturbance. Similarly, Hexagenia is generally associated with the soft mud bottom of lakes and banks of rivers (Lyman 1943, Smith and Isom 1967, Fuller 1974). Although the Tombigbee River typically possesses a good population of Hexagenia (Howell et al. 1978), Rattlesnake Bend collections were characterized

by a consistent occurrence and large abundance of this species. The presence of these two groups suggests that the substrate of Rattlesnake Bend is more uniform than that of the other bendways.

30. Another group, the Chaoboridae, is characteristically associated with standing water and is seldom very abundant in swift water habitats. This group accounted for only 3.1 percent of the Hairston Bend collections, but comprised from 21.2 to 25 percent at the other bendways.

31. One other dominant family of benthic invertebrates, the Hydropsychidae, may also be indicative of existing environmental conditions at the bendways. This group was especially numerous at Hairston Bend. Howell et al. (1978) considered members of this family to be indicative of natural river conditions.

32. With the exception of shells of Pleurobema marshalli and taitianum, no particularly uncommon species of Unionidae were taken from the Tombigbee River.

33. A preimpoundment study of Tombigbee River macrobenthos (Teledyne Brown Engineering 1975) showed that macroinvertebrates characteristic of swift currents and coarse substrates were common in the river stretch including Hairston Bend and Big Creek Bendway. In much of this area, particularly in the cutoff bendway at Big Creek, these taxa have been replaced by forms more tolerant of silt bottoms and slow currents.

34. Fish. Studies by Smith-Vaniz (1968), Caldwell (1969), and Boschung (1973) have reported a total of 116 fish species from the Tombigbee River system of Mississippi and Alabama. Pennington et al. (1981) reported 14,300 fish representing 79 species and 20 families. Gizzard shad (Dorosoma cepedianum) and threadfin shad (D. petenense) each comprised approximately 16 percent of the total catch. Important sport species, the bluegill (Lepomis macrochirus) and white crappie (Pomoxis annularis), made up 10.1 percent and 8.1 percent of the catch, respectively.

35. Due to differences in collecting methods, it is not possible to quantitatively compare previously published Tombigbee River fish

population studies with the WES study. Boschung (1973), for example, relied primarily on seines and trammel nets; his collections included many minnow and darter species, which are best collected by seining. Others (Cotton et al. 1969, Coleman 1969, Schultz 1971) also reported the results of a limited number of hoop net collections from the Tombigbee River in the general river reach immediately upstream of Hairston Bend. These results generally agree with Pennington et al. (1981), with two exceptions: Schultz (1971) reported smallmouth buffalo (*Ictiobus bubalus*) and carp (*Cyprinus carpio*) as abundant species, whereas Pennington et al. (1981) collected relatively few of these species.

36. The numeric catch per unit of effort (C/f) was nearly always higher in Rattlesnake Bend and Big Creek Bendway than in Cooks and Hairston Bends. The catch per unit of effort based on weight (C/y) generally reflected the pattern of the C/f. Big Creek Bendway was generally highest among the bendways in terms of species catch per unit of effort. Hairston Bend showed a relatively low species catch per unit of effort at any one sampling period, while its total species number was greatest. Conversely, Rattlesnake Bend had a relatively high species catch per unit of effort at any sampling period, but the fauna of this bendway was very constant over time.

37. The degree of similarity, based on the Kulczynski coefficient, between any pair of Tombigbee River bendways was related to their relative positions in a lock and dam pool. Two groups of bendways were loosely defined: an upper pool more riverine group (Hairston Bend and Big Creek Bendway) and a lower pool lentic group (Cooks and Rattlesnake Bends). The latter two have been pooled for several years and support fish faunas similar to southeastern U. S. reservoirs. Of the former two, Hairston Bend was pooled only late in the study and had no cut, and it remained essentially riverine during most sampling efforts. Big Creek Bendway was unique among the four bendways studied in having both a lentic and a riverine portion. For this reason the similarity of Big Creek to the other bendways was intermediate and varied widely across the sampling efforts.

38. Mean diversity values, based on the Shannon diversity index,

decreased and became more variable from Hairston Bend downstream to Rattlesnake Bend. Diversities for Hairston Bend, Big Creek Bendway, and Cooks Bend were similar, while the diversity at Rattlesnake Bend was considerably lower. There was no consistent tendency for bendway diversity values to covary among sampling dates.

39. The overall species composition of the four bendways differed both qualitatively and quantitatively. The number of species collected at the four bendways increased from Rattlesnake Bend upstream to Hairston Bend. Rattlesnake Bend yielded the fewest species of fish (43) and 53 species were collected from Cooks Bend. Big Creek Bendway and Hairston Bend yielded the greatest numbers of fish species: 58 and 60, respectively.

40. Large differences were apparent in the relative proportions of the major groups of fishes at each bendway. Sport fishes such as largemouth bass (*Micropterus salmoides*), white crappie and black crappie (*Pomoxis nigromaculatus*), bluegill and other sunfishes were relatively abundant at Big Creek Bendway, Rattlesnake Bend, and Cooks Bend. This species group was considerably less abundant at Hairston Bend. Similarly, gizzard and threadfin shad formed a large portion of the ichthyofauna at all except Hairston Bend. The minnows and shiners (Cyprinidae) were abundant in all bendways, but were most abundant at Hairston Bend.

41. Hairston Bend and Big Creek Bendway supported much larger populations of suckers than either Cooks Bend or Rattlesnake Bend. Even more so than the minnows and shiners, suckers are inhabitants of flowing water systems. Their peak abundance was reached at Big Creek Bendway (5.8 percent), within the influence of the tailwaters of the Aliceville Lock and Dam. Catfishes and the freshwater drum (*Aplodinotus grunniens*), species of both sport and commercial importance, were considerably more abundant at Hairston Bend and Rattlesnake Bend than at Big Creek Bendway and Cooks Bend. Channel catfish (*Ictalurus punctatus*) and blue catfish (*I. furcatus*) were dominant at Rattlesnake Bend, while channel catfish and flathead catfish (*Pylodictis olivaris*) were dominant at Hairston Bend.

42. The effect of the cuts at Rattlesnake and Cooks Bends was

confounded by the effect of pooling. It appears overall, however, that the effect on the fish community due to pooling is more important.

43. In Big Creek Bendway, the effect of the cut was to produce two distinct fish habitats: a riverine one in the area below the Aliceville Lock and Dam complex and a lentic environment in the cutoff bendway. Here the effect of pooling was of less importance in structuring the fish community. Hairston Bend had no cut section during the study, nor was it pooled for a sufficient length of time to demonstrate the faunal changes shown in the other bendways.

44. Over a series of years, both riverine and impoundment habitats show fluctuations in their faunas. After the first few years impoundments tend to have relatively stable species complements, but the relative abundances of the species may vary and often cyclicly. Jenkins (1979) has noted the overriding importance of environmental conditions in regulating species abundance in reservoirs. Streams, on the other hand, tend to vary both in species complement and relative abundances over a series of years (Cross and Braasch 1968, Rinne 1975, Whitaker 1976, Horwitz 1978). Within the Tombigbee River study area, Rattlesnake and Cooks Bends illustrated the former situation, while Hairston Bend, and to a lesser extent Big Creek Bendway, illustrated the latter.

45. Fish communities in lentic environments are typically dominated by predaceous species that are the principal targets of sport and commercial fishermen (Bhukaswan 1973, Noble 1980). Prey species in southeastern U. S. impoundments are predominantly clupeids (shad) and small centrarchids (sunfishes); cyprinids (minnows and shiners) are usually of lesser importance as prey (Noble 1980).

46. The evidence from the four bendways suggests that the river section of the TTW is presently undergoing faunal changes typical of impoundments in most parts of the world. The general pattern following impoundment is one of a decrease in both diversity and number of species. This is due to several factors, but the loss of microhabitats associated with fast currents may be of the greatest significance (Bhukaswan 1973). Although the time for the change to be completed may vary from about 5 years (Beckman and Elrod 1971, Patriarch and Campbell 1958) to over

11 years (Bhukaswan 1973), the specific changes are reasonably well understood. These changes include elimination or reduced abundance of flowing water species, and a rapid increase in the abundances of sport fishes and, usually, shad (Schoonover and Thompson 1954, Carter 1968, Turner 1971, Spence and Hynes 1971).

47. Marzolf (1978) stated that channelization alters stream velocity, alters sediment particle-size distribution and removes natural cover (logs and overhanging trees). Stream channelization also reduces diversity, size, and number of fish. Full recovery of a fishery, however, requires less than 10 years (Schoof 1980). A survey of 300 miles of the Missouri River by Groen and Schmulbach (1978) indicated that the standing crop of sport fish was less in the channelized than the unchannelized river. They attributed this difference to more backwater habitat and greater habitat diversity in the unchannelized river. The impact of channelization in prairie streams of central Iowa was thought to be minimal when confined to limited stretches of low gradient flow (Menzel and Fierstine 1976).

48. Although cutoff bendways provide habitat for certain types of fishes, channelization results in a net loss of lotic habitat (Congdon 1971, Barton et al. 1972, King and Carlander 1976). The most significant result of a study of two cutoff bendways on the Lower Alabama River (Shipp and Hemphill 1974) was that game fish populations were higher in the bendways than in adjacent river reaches. Reasons stated included the greater availability of suitable habitats, reduction of current, diversion of barge traffic, and retention of sandy banks. The study concluded that channel cuts creating cutoff bendways, "if done in moderation," are not detrimental to fish populations and may be beneficial for some species, provided that sufficient flow be maintained in the bendway to maintain sandy banks.

Summary

49. Bendway cutoffs and impoundments of the river by locks and dams were the two overriding ecological factors that influenced the

results of the WES study. The concurrent impoundment of the river and the dredging of the cutoff channels undoubtedly masked effects that might have been attributed to one or the other factor had they occurred independently. Although the effects of these factors (i.e., impoundment and cut off) are often confounded, impoundment behind the lock and dam complexes primarily affects the more downstream areas of the pools, while bendways in the upper more riverine portions of the pools may be affected more seriously by the channel cuts.

50. The evidence from the four bendways indicates that the river section of the TTW is undergoing faunal changes, i.e., a decrease in both diversity and number of species. The loss of microhabitats associated with fast currents may be of greatest significance.

51. The cutoff bendways, analogous in many respects to oxbow lakes, will provide habitat that would not be found along the main navigation channel. Due to construction activities, main navigation channel segments will contain few structural features considered important as fish and wildlife habitat, e.g., backwaters, sinuous shorelines, and submerged brush and trees. Cutoff bendways will remain relatively unaltered in these respects, and they can be expected to provide a significant recreational resource.

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